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Fluorescence study of SrS : Ho phosphors

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The fluorescence spectra of SrS:Ho phosphors studied consist of two bands (6450Å and 5740Å) at lower concentration of activator. On increasing the concentration of activator a third band at 4740Å and a number of lines superimposed on bands are observed. The intensity of lines incrases with further increase of activator concentration upto its optimum value (0.035 gm) thereafter decreases and then few lines are quenched. It is suggested that alongwith the multiplicity of ground state the excited state may also be splitted to a comparable degree and the lines are emitted as a result of transition from different excited state to the ground state.

1. Introduction

The fluorescence spectra of trivalent rare-earth ions incorporated in various lattices have been investigated by several workers (Dieke 1968, Arsenev & Bienert 1972, Rao 1973). In the present investigation the fluorescence spectra of strontium sulphide activated with holmium have been studied in an attempt to determine the nature of luminescence centres responsible for emission of spectra.

2. Experimetal Details

The phosphors were prepared as reported by the authors in an earlier paper (Jain & Sinha 1974). The fluorescence spectra were recorded with a steinheil spectrograph using the Raman unit. The sample holder was a cavity of diameter about 2 cm cut in an ebonite plate. The phosphor was placed in it and was covered by a quartz plate. The phosphor was excited by ultraviolet light (3650Å) and fluorescence spectra were recorded on R-40 plate. The spectral intensities of lines and bands were measured on a Carl Zeiss microphotometer connected with an automatic recorder G1B1.

3. Results

It is observed that in fluorescence spectra of SrS:Ho phosphors two bands appear at lower concentration of holmium (0.0001 gm) with peaks at 6450Å and 5740Å. As the concentration of holmium is increased third band appears with the peak at 4740Å. On further increase of activator concentration (0.0075 gm), lines superimposed on bands in the range of 4626Å to 6500Å are observed. These

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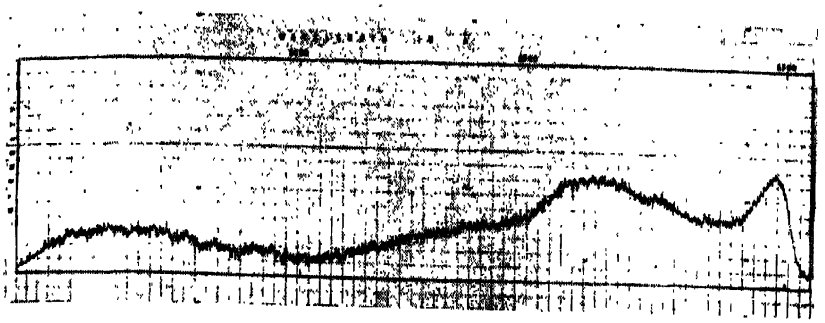

Fig. 1. Variation of intensity of fluorescence bands with wave length.

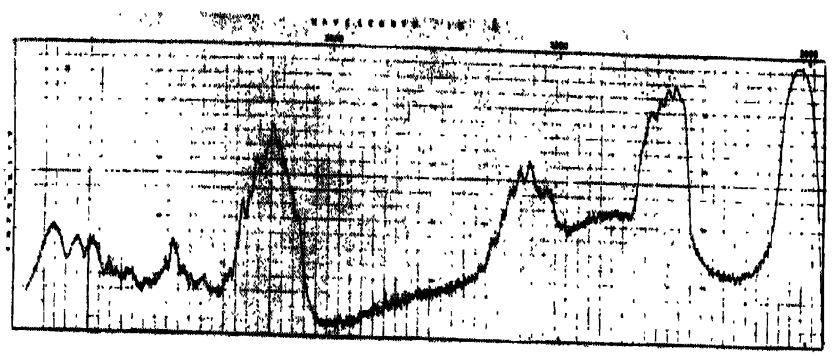

Fig. 2. Variation of intensity of fluorescence lines with wave length.

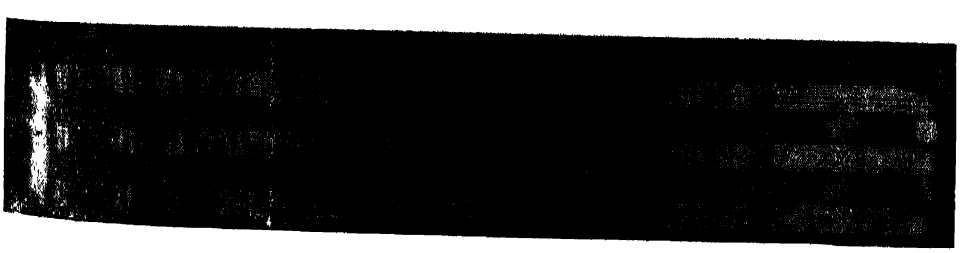

Fig. 3. Photographic plate of fluorescence spectra.

lines grow in intensity with further increase in concentration of Ho^{3+} upto its optimum value (0.035 gm), thereafter lines start getting weak and few lines are quenched at higher concentration. There is no peak shift in the bands with activator concentration allowing for an uncertainity of about $\pm$20Å in the estimation of peak, but both the bands 5740Å and 4740Å increase or decrease in intensity together.

4. Discussion

The plausible explanation of the double band emission is sought on the basis of different theories. Sometimes the base material has its characteristic emission in addition to one due to activator. If one of the band is due to the contribution of the host the intensity should have been decreased with the increase of activator concentration (Fonda 1948, Leverenz & Seitz 1939), therefore, this possibility is remote. The possibility of mixed phosphor is also ruled out on the basis of the X-ray studies undertaken as a part of the present work, which reveals that SrO is not formed during heat treatment which emit bands in the different region (Pringsheim 1949). The two emission centre mechanism (Klick 1955, Maurer 1948) can be eliminated because of the fact that in this case one band develops at the cost of the other. The band gap of SrS is 4.8 eV and the traps case are found to be situated at about .0.70 eV (Jain & Sinha 1974) below the bottom of conduction band. The deepest trap reported for alkaline earth sulphide phosphors are at about 1.2 eV (Curie 1963). The energy required for trap emission in the above two case are 4.1 eV and 3.6 eV respectively. The two emissions obtained in the present case are lying at 2.61 eV and 2.15 eV. Thus it is clear that the trap emission mechanism is not applicable in the present case (Klasens 1953). However, the presence of two bands may be explained by assuming a common level for the two bands (Sinha & Sivraman 1972, Levshin 1966) due to some defect in the host lattice itself.

Keller (1958) has reported that when holmium is incorporated in SrS lattice six peaks appear in the fluorescence spectra in a bell shaped band spreading from 4000Å to 6000Å at room temperature. Larach (1966) investigated the emission of Ho in ZnS and reported three bunches of lines and one band. One bunch at 4700Å ($^5G_2 \rightarrow {}^5I_5$) second at 4900Å ($^5F_3 \rightarrow {}^5I_8$) and third at 5500Å ($^5S_2 \rightarrow {}^5I_8$) and the band situated approximately between 6000Å to 7000Å. Willi-Lehman (1972) has reported many lines from blue to infra-red region in the case of CaS:Ho phosphors main groups situated at 1.85, 2.10, 2.28, 2.52 and 2.92 eV.

In the present case 27 lines are observed in the fluorescence spectra of SrS:Ho phosphors, 6 lines around 4700Å (4626Å-4752Å), 9 lines around 4900Å (4858Å-4957Å), 6 lines around 5450Å (5367Å—5510Å) and 6 lines around 5900Å (5843Å-5994Å). Thus the result in the present case is similar to what has been reported by Keller, Larach and Willi-Lehmann in SrS, ZnS and CaS lattices respectively.

The spectra could be treated as if there was a single excited state and a multiplicity of ground state or vice-versa. The ground state of holmium as given by Hund's rule is $^5I_8$. In the rare-earths Russell-Saunder's approximation holds and L.S. coupling is effective due to the shielding of $4f$ electrons from the crystal field by $5s$ and $5p$ electrons (Keller 1959). The different orientations of the spin s and orbital moment l vectors, of $4f$ electrons in the incomplete shell give rise to several quantum states. Transitions among which result in fairly sharp lines.

The assumption of single exicited state and the multiplicity of ground state can account for only a few of the observed lines. This suggests that the excited state may also split to a comparable degree thus increasing the number of allowed transitions. The lines are emitted as a result of transitions from different excited states to the ground state. However, because of the complex nature of the spectra it is difficult to ascertain the transitions responsible for various lines.

The bands observed at 6450Å may be due to non-resolution of lines due to limitation of instrument and plate used, because Willi-Lehmann (1972) has reported lines in this region when Ho was incorporated in CaS lattice. This may be sharp cut-off of intensity or due to diffusion of close lines at the lower wavelength-edge of the infra-red or due to some unpredictable reasons.

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